U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-271 887

Assessment of Railroad Fuel Use and Emissions for the Regional Air Pollution Study

Abcor, Inc, Wilmington, Mass Walden Research Div

Prepared for

Environmental Protection Agency, Research Triangle Park, N C Office of Air Quality Planning and Standards

Apr 77

EPA-450/3-77-025
April 1977

PB 271 887

ASSESSMENT OF RAILROAD FUEL USE AND EMISSIONS FOR THE REGIONAL AIR POLLUTION STUDY

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/3-77-025	2.
3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE ASSESSMENT OF RAILROAD FUEL USE AND EMISSIONS FOR THE REGIONAL AIR POLLUTION STUDY	5. REPORT DATE April 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Kenneth W. Wilsee, Jr., Shashi B. Khanna, and James C. Hanson	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Walden Research 850 Main Street Wilmington, MA 01887	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO. 68-02-1895
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC 27711 / Department of Trans. Trans System Center Cambridge, MA 02142	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE 200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

A methodology has been developed for calculating and reporting fuel use and air pollutant emissions from railroad locomotive activity. The procedure utilizes automated techniques to report rail activity on a variable-sized grid system. Separate methodologies were developed for the two major types of rail activity - road or line-haul operation and activity within switch yards. The methodology for road locomotives utilizes a line source concept and synthesizes the rail network by a series of links connecting a system of node points within the study area. The methodology for switch yard operation utilizes an area source concept. Both methodologies use as a basic unit locomotive horsepower-hours and were programmed to provide an analysis of fuel use and emissions for five criteria pollutants on a grid-by-grid basis as well as for the entire study area.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Regional Air Pollution		
Fuel Use		
Emissions		
Air Pollution		
Emission Inventory		

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS (This Report)	21. NO. OF PAGES 75
	20. SECURITY CLASS (This page)	22. PRICE

EPA Form 2220-1 (9-73)

EPA-450/3-77-025

ASSESSMENT OF RAILROAD FUEL USE AND EMISSIONS FOR THE REGIONAL AIR POLLUTION STUDY

by

Kenneth W. Wilson, Jr., Dr. Shashi B. Khanna, and James C. Hanson

Walden Research
850 Main Street
Wilmington, Mass. 01887

Contract No. 68-02-1095
Task Order No. 2

EPA Project Officer: Charles C. Masser

Prepared for

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

and

U.S. Department of Transportation
Transportation Systems Center
Cambridge, Massachusetts 02142

April 1977

1-a

This report is issued by the Environmental Protection Agency to report technical data of interest to a limited number of readers. Copies are available free of charge to Federal employees, current contractors and grantees, and nonprofit organizations - in limited quantities - from the Library Services Office (MD-35), Research Triangle Park, North Carolina 27711; or, for a fee, from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

This report was furnished to the Environmental Protection Agency by Walden Research, 850 Main Street, Wilmington, Massachusetts, in fulfillment of Contract No. 68-02-1899, Task Order 2. The contents of this report are reproduced herein as received from Walden Research. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency. Mention of company or product names is not to be considered as an endorsement by the Environmental Protection Agency.

Publication No. EPA-450/3-77-025

TABLE OF CONTENTS

Section		Page
I	INTRODUCTION	1-1
II	SUMMARY	2-1
III	METHODOLOGY	3-1
	A. Allocation of Railroad Activity	3-2
	1. Data Collection and Preparation	3-2
	2. Locomotive Classification	3-2
	3. Software Development	3-8
	B. Computation of Fuel Use and Emissions	3-14
IV	RESULTS	4-1
V	REFERENCES	5-1
	APPENDIX A - Computer Program Descriptions and Runstreams	A-1
	APPENDIX B - Input Data Coding Formats	B-1
	APPENDIX C - Fuel Use and Emissions by Grid	C-1

ACKNOWLEDGEMENTS

Walden Division of Abcor, Inc., extends its appreciation to the U.S. Environmental Protection Agency and to the U.S. Department of Transportation Transportation Systems Center for jointly sponsoring this work.

We also extend our appreciation to Mr. David Knapton of Raytheon Company and Mr. John Pierre of Rockwell International for their assistance in data collection. Mr. J.B. Buffalo of the St. Louis Terminal Railroad Association provided invaluable assistance in identification of the railroad geography.

The cooperation of the EPA project officer, Mr. Charles C. Masser, throughout the project is also greatly acknowledged.

Ms. Linda Fereshetian provided many hours of effort in coding the data. The manuscript was prepared under the direction of Ms. Gail Kelleher.

I. INTRODUCTION

The Regional Air Pollution Study (RAPS), using as a study area the St. Louis Air Quality Control Region, (AQCR) is the largest and most comprehensive attempt to date to obtain a quantitative understanding of urban air pollution. Its aim is to describe the complex relationship between emissions to the atmosphere, atmospheric transport and transformation processes, and ambient concentrations of pollutants.

An accurate, detailed and comprehensive inventory of emission to the atmosphere constitutes a basic input to this understanding. The RAPS emission inventory was designed to provide more detailed information, spatially and temporally, than has been available in the past. The objective is to provide emission data commensurate in detail and accuracy with data on ambient concentrations and micrometeorology.

The objective of the current study was to develop a methodology for estimating fuel use and emissions from locomotives operating in the St. Louis AQCR and to allocate these estimates to the RAPS area source grid system. Railroad emissions of some pollutants have been estimated to comprise up to ten percent of total area source emissions in the AQCR [1] and, in areas of heavy rail activity, can have a significant impact on ambient air quality concentrations.

This report describes the methodology developed to estimate and allocate rail emissions and presents the results of its application to the St. Louis AQCR. As with many of the models developed for RAPS, this allocation methodology can be easily applied in other areas of the country. For this reason, a manual for coding the necessary input data (Appendix B) and examples of the control cards necessary to utilize the software package on the RTP UNIVAC 1110 computer are included (Appendix A).

II. SUMMARY

A methodology has been developed for calculating and reporting fuel use and air pollutant emissions from railroad locomotive activity. The procedure utilizes automated techniques to report rail activity on a variable-sized grid system.

Separate methodologies were developed for the two major types of rail activity - road or line-haul operation and activity within switch yards. The methodology for road locomotives utilizes a line source concept and synthesizes the rail network by a series of links connecting a system of node points within the study area. The methodology for switch yard operation utilizes an area source concept. Both methodologies use as a basic unit locomotive horsepower-hours and were programmed to provide an analysis of fuel use and emissions for five criteria pollutants on a grid-by-grid basis as well as for the entire study area.

Locomotive diesel engine fuel use and emissions vary considerably among the various engine types, sizes, and modes of operation. Thus, it was necessary to categorize each locomotive of the three principal manufacturers into one of five engine categories based on horsepower rating and maker. Load factors, representing the average portion of available horsepower typically used in performing an activity, were derived from previous studies.

Application of this methodology in the St. Louis AQCR required an inventory of railroad activity. This inventory was supplied by the U.S. Department of Transportation, Transportation Systems Center [2], and included information on the routing, run time, and locomotive(s) for each train in operation on a typical day plus estimates of switch yard and transfer activity. Fuel use and emission factors used in this study are those presented in the Environmental Protection Agency's document, Compilation of Air Pollutant Emission Factors (AP-42) [3].

This study was designed to inventory emissions only from diesel locomotive operations as diesel exhaust represents the most significant source of railroad emissions. The quantity of emissions from auxiliary engines in rolling stock and from evaporation and spillage of fuel and volatile freights have thus not been evaluated.

Application of this methodology in the St. Louis AQCR indicated that approximately 800 of the 1,850 grids comprising the RAPS grid system contained railroad activity. Annual fuel use by locomotives was estimated at 70,100 thousand gallons and total AQCR rail pollutant emissions are as follows:

Pollutant	Emissions (tons/yr)
Particulates	876
Sulfur Oxides	2,000
Carbon Monoxide	4,350
Hydrocarbons	4,220
Nitrogen Oxides	11,930

Locomotive emission factors (measured as pounds of pollutant emitted per thousand gallons of fuel used) were derived based on the mix of engine types in St. Louis. Comparison of these factors were similar values computed from a "nationwide" mix (and presented in "AP-42") indicated little difference except for hydrocarbons. The AQCR hydrocarbon emission factor is approximately 30 percent greater than the national average.

III. METHODOLOGY

Development of the methodology required to compute annual fuel use and emissions from locomotives by RAPS grid square involved two phases. The first was the allocation of railroad activity to the grids and the second was computation of fuel use and emissions.

The basic unit used in allocating activity to grids was the "horsepower-hour"*. Separate techniques were employed for allocating road activity and yard activity to grids. In summarizing road locomotive activity by grid, each train was represented as a line source and the amount of time each train spent in each grid, weighted by the horsepower being used to move the train, was summed by grids. Yard activity was estimated by determining the total activity in each yard, both from idling and active engines, and allocating this activity to grids based on the portion of the yard area contained in each grid.

In performing the allocation task, locomotive activity was classified by five engine "types" as well as by grid. This was necessary due to the difference in emission and fuel consumption characteristics of the five types of diesel engines which are presently in operation. (These types are listed in the following section). All locomotives were placed into one of the categories based on manufacturer and rated horsepower.

Computation of fuel use and emissions for each grid was accomplished by deriving fuel consumption and pollutant emission factors as a function of engine type and applying these factors to railroad activity.

The following sections describe the methods developed to accomplish each of these tasks and the results obtained.

---

* Horsepower-hour is a unit of work which represents generation of one horsepower for one hour.

A. ALLOCATION OF RAILROAD ACTIVITY

1. Data Collection and Preparation

As part of the development of the emission inventory for the Regional Air Pollution Study the U.S. Department of Transportation, Transportation Systems Center, supplied a complete inventory of railroad activity including:

- Routing, runtime and locomotive information for each train in the study area
- Total active and idle hours and locomotive information for each rail yard in the AQCR
- Interyard transfer routing and runtime

These data were compiled based on a one day sample taken on Wednesday July 17, 1974. The data were assumed to represent annual average 24-hour activity [2]. Also required were U.S.G.S. topographic maps of the area with the grid system overlaid.

These data were put into a computer-compatible format. A total of seven information files were created; the information included in these files is presented in Table 3-1.

The basis for simulating the rail network is a system of links comprised of straight segments which connect node points in the study area. The "nodes" are defined to be the significant checkpoints of the system such as the points were rail lines cross the study area boundary, control towers, and railroad yards. The movement of a train between two nodes takes place along a rail line which is defined as a "link". A link is defined by its origin node and destination node and is comprised of a series of straight line "segments" which simulate the geometry of the actual rail system as seen on a map.

Appendix B presents a manual for coding the information indicated in Table 3-1.

2. Locomotive Classification

As noted above, the goal of the allocation task is to determine, by engine class and grid, the total number of horsepower-hours expended. One

TABLE 3-1

RAIL ACTIVITY ALLOCATION FILES

File	Contents
Grid	Coordinates (UTM) of southwest corner, size, and identification number
Rail Segments	Coordinates (UTM) of straight rail segments keyed sequentially and by the link (org-des) they comprise. (See text for further information).
Road Train Activity	Two-card entry for each road train in study area: Card 1 - locomotive information; Card 2 - routing and runtimes
Transfer Hours	Number of hours of transfer engine activity between each rail yard
Yard Activity	Number of switch engine active and idle hours in each yard plus an indication of typical engine types for that yard
Road Train Idling	Number of road locomotive idling hours for each yard including locomotive information
Yard Location	The grids which contain each yard and an estimate of the portion of the yard in each grid

Note: Locomotive information includes number of engines and the manufacturer and horsepower of each.

important task was to investigate the locomotives in operation in the St. Louis AQCR to determine engine type and typical operating factors. Three tasks were performed to achieve this objective:

- Classification of locomotives into the five engine categories specified in AP-42 [3].
- Derivation of active and idle load factors for switch and road locomotives
- Characterization of a "typical" transfer engine used in the St. Louis AQCR

a. Engine Types

The public relations departments of General Motors, Montreal Locomotive Works, and General Electric, the three locomotive manufacturers with engines operating in the St. Louis area, were contacted [4,5,6] to obtain the information necessary to categorize each locomotive operating in the St. Louis AQCR into the five "AP-42" categories. These categories are:

- 2 - Stroke Supercharged Road
- 2 - Stroke Turbocharged Road
- 4 - Stroke Road
- 2 - Stroke Supercharged Switch
- 4 - Stroke Switch

Table 3-2 presents the results of this categorization.

b. Load Factors

The portion of the available locomotive horsepower which is utilized during normal operation is the load factor. This factor is defined as the average horsepower produced during operation divided by the available power. AP-42 [3] suggests a typical load factor of 0.4 for a line haul (road) locomotive and 0.06 for a switch engine. These numbers are based on data in a recent EPA - sponsored research study [7]. However, it was decided not to use these load factors directly as they implicitly assume a mix of both active and idle time. In the St. Louis railroad activity information base, the hours of active and idling time are explicitly recorded.

TABLE 3-2

CATEGORIZATION OF LOCOMOTIVE TYPES IN ST. LOUIS RAIL ACTIVITY INVENTORY

Maker	Horsepower Range	Engine Type
ALCO (Montreal Locomotive)	1,000	4-Stroke Switch
ALCO (Montreal Locomotive)	1,600-2,000	4-Stroke Road
General Electric	600	4-Stroke Switch
General Electric	2,500-3,300	4-Stroke Road
General Motors (EMD)	600-1,500	2-Stroke Supercharged Switch
General Motors (EMD)	1,600-2,300,2,500	2-Stroke Supercharged Road
General Motors (EMD)	2,400,2,750-3,600	2-Stroke Turbocharged Road

Thus, four load factors, corresponding to active road locomotive, idling road locomotive, active switch engine, and idling switch engine, were derived for this study.

The data required for constructing the four load factors was obtained from the Southwest Research Institute (SWRI) report [7] and from telephone conversations with General Motors personnel [4]. The SWRI study gives the following duty cycles for a switch locomotive and a road locomotive.

LOCOMOTIVE DUTY CYCLES

Throttle Setting (Notch)	Percent of Operating Time in Notch Switch	Road
Idle	77	41
Dynamic Brake	--	8
1	10	3
2	5	3
3	4	3
4	2	3
5	1	3
6	1	3
7	0	3
8	0	30

The duty cycle gives the percent of operating time in each throttle position or notch. General Motors Electro-Motive Division provided data on the horsepower produced at each throttle position for both a typical switch and a typical road locomotive.

ENGINE HORSEPOWER BY THROTTLE SETTING

Throttle Setting (Notch)	Engine Horsepower Switch	Road
Idle	24	50
Dynamic Brake	--	100
1	100	100
2	210	340
3	375	645
4	575	980
5	785	1400
6	1015	1890
7	1250	2640
8	1500	3060

To calculate load factors at idle, the ratio of horsepower produced at idle to total available horsepower was used.

For a switch engine, idle load factor = $\frac{24}{1500}$ = 0.016

For a road locomotive, idle load factor = $\frac{50}{3060}$ = 0.016

To calculate load factors for an active locomotive, the percentage of operating time in each <u>running</u> throttle position (i.e., other than the idle portion) was normalized and the average horsepower calculated.

The active load factors were 0.19 and 0.65 for switch and road locomotives, respectively.

As a check, composite load factors for both switch and road engine types were calculated and compared to those from AP-42. The results are tabulated below and indicate no significant difference.

COMPOSITE LOAD FACTOR COMPUTATION

Engine	Time Idling (percent)	Idle Load Factor	Time Running (percent)	Running Load Factor	Composite Load Factor	AP-42 Load Factor
Switch	77	0.016	23	0.19	0.056	0.06
Road	41	0.016	59	0.65	0.39	0.4

c. Characterization of a Typical Transfer Engine

The final task in the classification of St. Louis locomotives was the characterization of the typical transfer engine operating between area yards. Since specific information on the type of engines transferring rolling stock between yards was not specified in the rail inventory, switching engines active inside the area yards were used to derive a typical transfer engine in terms of horsepower and mix of engine types. An average locomotive horsepower weighted by active operating hours for each of the switch engine categories was calculated. The average engines are as follows:

Type	Average Horsepower	Active Hours	Percent of Total Active Hours
2-Stroke Supercharged	1300	1167	85
4-Stroke	1030	205	15

In allocating transfer activity to grids, the above factors were used in conjunction with the active yard engine load factor to compute horsepower-hours. The equation to be used is:

$$\text{Work (switch engine type}_i\text{, transfer)} = HP_i * LF * PCT_i * THR$$

where:

Work (switch engine type$_i$, transfer) = Work output (hphr) in transfer activities of engine type$_i$

HP_i = average locomotive horsepower for engine type$_i$

LF = active yard engine load factor (0.19)

PCT_i = portion of total transfer hours represented by engine type$_i$

THR = total transfer hours in grid

3. Software Development

A battery of computer programs was developed to perform the railroad activity allocation. Included was a program to preprocess the grid information, several programs to provide a quality assurance of the data, and the actual allocation programs. The methodology used in developing these computer programs is briefly described in this section. A complete description of these programs including flow charts and run streams is presented in Appendix A.

A. Overview of Computer Processing

Figure 3-1 presents an overview of the methodology to be employed. The center column lists seven computer programs (identified by rectangles) which were developed. The relationship of these programs to the various input files and the purpose and subsequent use of the output data sets are generally indicated along the left and right sides, respectively, of the diagram. Each of the computer programs is described in the following subsections.

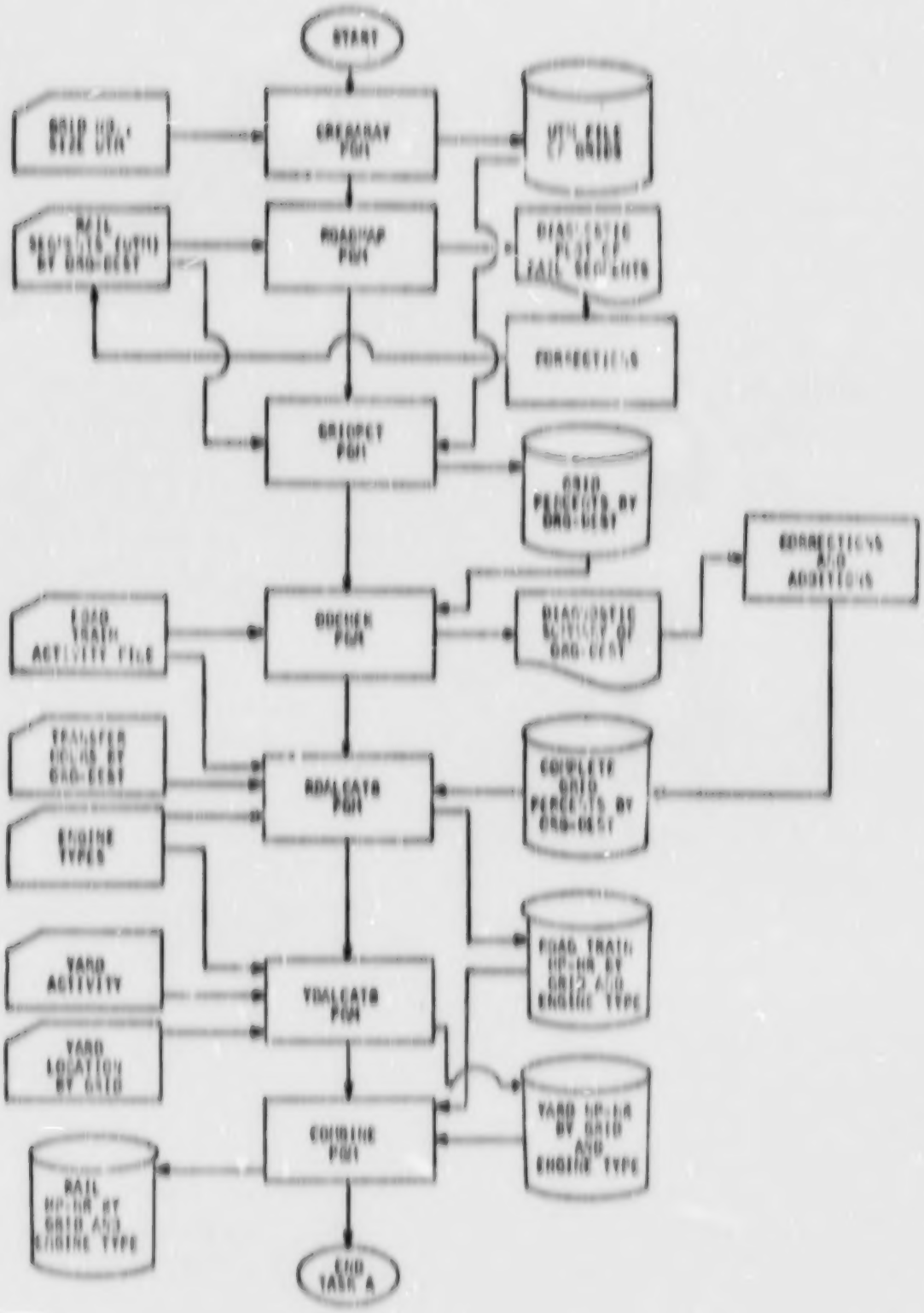

FIGURE 3-1
OVERVIEW OF COMPUTER PROCESSING METHODOLOGY

b. Grid Preprocessing Program (CREGARAY)

The purpose of this program is to provide a cross-reference of grid number and boundary location as a function of UTM coordinate. The input to the program is the RAPS grid system including grid number, southwest corner coordinates, and grid size (area). The program assigns to each integral UTM coordinate pair within each grid and to the west and south boundaries of that grid, a location indicator and the grid number. The location codes are:

Code	Condition
0	Not in AQCR
1	Corner of a grid
2	"X" boundary but not a "Y" boundary
3	No boundary
4	"Y" boundary but not an "X" boundary

This program builds an array of codes and grid numbers which are output to disk for use by the subsequent programs.

c. Link Plotting Program (ROADMAP)

The purpose of this program is to provide a plot of the rail node and link network as coded from the U.S.G.S. maps in order to identify coding and keypunching.

ROADMAP is an existing Walden computer program which displays a set of highway or rail links on a Calcomp plotter. The output of this program provides a visual check of the accuracy of rail link coding and will thus serve as the basis for correcting input link data. Figures 3-2 and 3-3 present the St. Louis AQCR rail network as used in this study.

d. Links-to-Grids Program (GRIDPCT)

This program determines the length of each link between each origin and destination (node) and the percent of this length which is included in each grid. The inputs to the program include the cross-reference

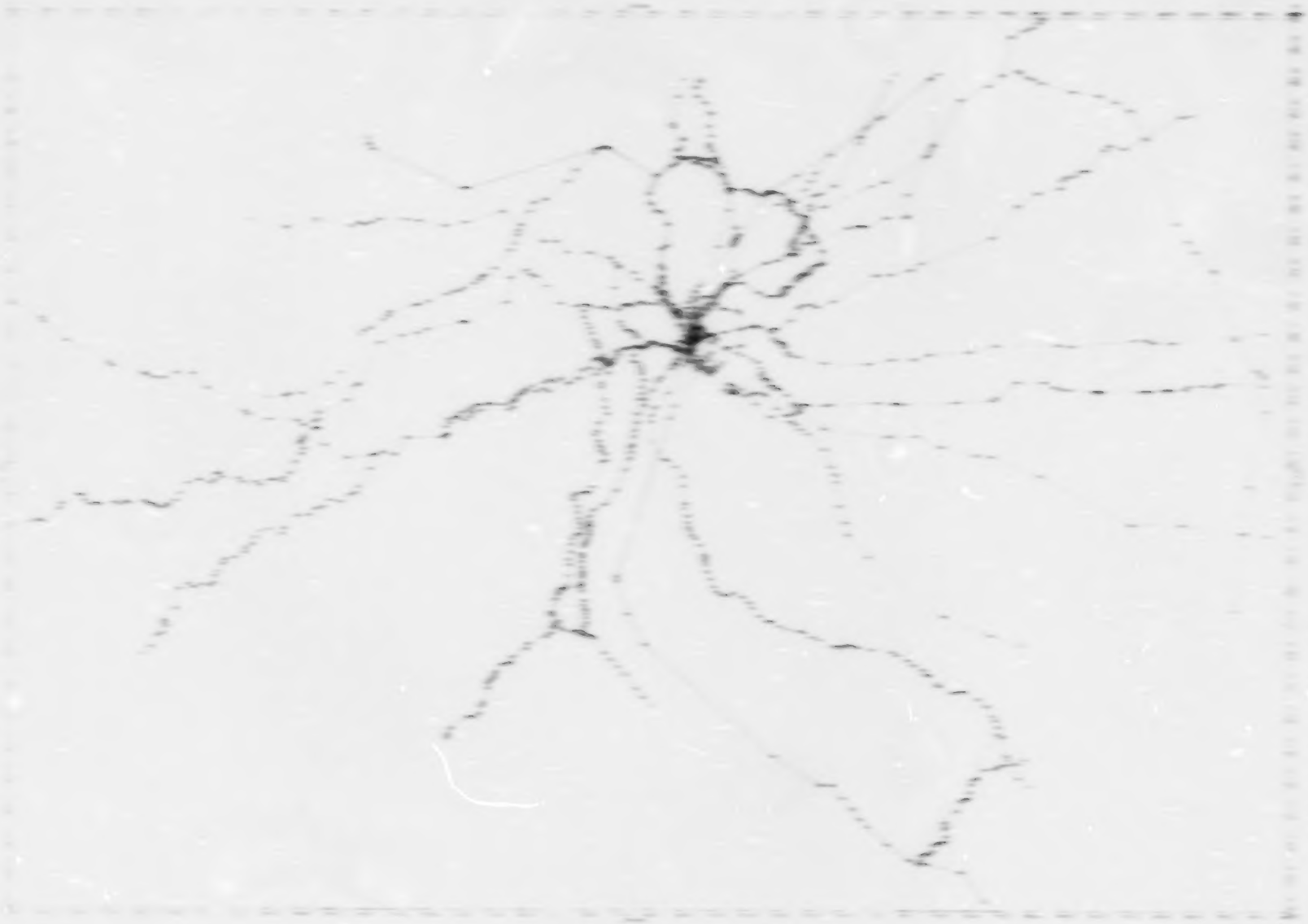

FIGURE 3-2 ST. LOUIS RIVER RAIL NETWORK

FIGURE 3.3 EXPANDED VIEW OF ST. LOUIS/E. ST. LOUIS RAIL NETWORK

file output by CREGARAY plus the card file of coded rail segments corrected by means of the ROADMAP plot.

This program determines for each rail segment comprising a rail link between a given origin and destination:

- the grid(s) containing each end of the segment,
- the grids not containing the end points but which are intersected by the segment,
- the length of the segment in each grid
- a running total

After processing all links and segments the length of rail by grid is normalized and three files are output to disk. These are:

- The length of each link connecting an origin-destination
- A file of grids containing the percent of each link the grid contains
- A cross-reference key for these files

e. Rail Activity Quality Control Program (QDCHEK)

This program provides a quality assurance check on the routing of road trains. The inputs include the card file of rail routing plus the cross-reference key created by the GRIDPCT program. This program provides a printout of origin-destinations which were not represented by the first coding of rail links. Two conditions cause an origin-destination to be flagged. These are:

- The TSC study [2] skipped certain intermediate nodes in providing the routing or,
- A keypunch or coding error occurred.

Corrections and additions to the input files were made as a result of the processing.

f. Allocation of Road and Transfer Train Activity (RDALCATB)

The purpose of this program is to allocate non-yard activity to grids. The inputs include the road and transfer train activity*, the outputs of GRIDPCT, and a file of engine types. This program determines for each rail activity, the horsepower-hours by engine type used between two nodes and then allocates this to the grids containing the link which connects the two nodes. The output of this program is total horsepower-hours from non-yard activity by grid and engine type.

g. Allocation of Yard Activity (YDALCATB)

This program allocates locomotive activity in yards to the grid system. The program uses switch engine activity (idle and active) and road engine idling by yard, plus a file of grid number and percent by yard coded from the U.S.G.S. maps and an identification of engine types. Activity in the yards is summed by grid number and engine type.

h. Program to Merge Files (COMBINE)

This program combines the road and yard activity files into a master file which summarizes all locomotive activity (horsepower-hours) by grid and engine type. The program uses the output files of RDALCATB and YDALCATB. The results of this program are the total AQCR locomotive activity measured in horsepower-hours and summarized by RAPS grid and engine type.

B. COMPUTATION OF FUEL USE AND EMISSIONS

The second phase of the analysis was conversion of the rail activity file to estimates of annual fuel use and emissions for each grid. To achieve this, a computer program was prepared. The input to this program was the file of total daily horsepower-hours by grid and engine type (created by the program COMBINE). The output includes a card file of annual fuel use by

* Activity includes routing (origin and destination) and runtime

engine type, grid fuel use, and total grid emissions of five pollutants; a print file presenting total annual fuel use and emissions by grid; and an AQER summary file which is the summation of computed grid fuel use and emissions.

The program computes fuel use per horsepower-hour using factors derived from AP-42. These fuel use rates are as follows:

Engine Category	Fuel Consumption (gallons/hp-hr)
2 Stroke Supercharged Switch	0.097
4 Stroke Switch	0.076
2 Stroke Supercharged Road	0.059
2 Stroke Turbo-Charged Road	0.055
4 Stroke Road	0.047

Fuel consumption in each grid was computed by the equation:

$$F_i = \sum_{j=1}^{5} (U_j)(P_{i,j})(365)$$

where:

F_i = Annual fuel use in $Grid_i$ (gallons)

U_i = Fuel Consumption by Engine $Category_i$ (gallons/hp-hr)

$P_{i,j}$ = Work by locomotives of engine $category_j$ in $grid_i$ (hp-hr)

365 = Factor to convert daily to annual consumption [2]

Emissions of the five criteria pollutants* in each grid were computed using the following:

$$Q_{i,k} = \sum_{j=1}^{5} (E_{j,k})(P_{i,j})(0.000403)$$

* Sulfur dioxide, particulates, nitrogen oxides, hydrocarbons, and carbon monoxide

where:

$Q_{i,k}$ = Emissions of pollutant$_k$ in grid$_i$ (tons/year)

$E_{j,k}$ = Emission factor for pollutant$_k$ resulting from operation of engine category$_j$ (grams/hp-hr)

0.000403 = Factor to convert grams/day to tons/year

Table 3-3 presents the emission factors, $E_{j,k}$, used in this study [3].

TABLE 3-3

LOCOMOTIVE EMISSION FACTORS
(grams/horsepower-hour)

Engine Category	Pollutant				
	Carbon Monoxide	Hydrocarbon	Nitrogen Oxides	Sulfur Oxides	Particulates
2-Stroke Supercharged Switch	3.9	8.9	11.	2.5	1.1
4-Stroke Switch	13.	5.0	17.	2.0	0.9
2-Stroke Supercharged Road	1.8	4.0	9.4	1.5	0.7
2-Stroke Turbocharged Road	4.0	0.7	8.2	1.4	0.6
4-Stroke Road	4.1	2.2	10.	1.2	0.5

IV. RESULTS

Appendix C presents the annual fuel use and emissions for each grid in the RAPS study area which contains railroad activity. Annual locomotive fuel use in the AQCR was calculated to be 70,870 thousand gallons.

Total AQCR emissions of five criteria pollutants emitted by railroads were derived through summation of the grid emissions. The results are as follows:

Pollutant	Emissions (tons/yr)
Particulates	878
Sulfur Oxides	1,997
Carbon Monoxide	4,350
Hydrocarbons	4,270
Nitrogen Oxides	11,935

The average emission factor for each pollutant was then calculated for the AQCR by dividing total emissions by total fuel use. These emission factors based on the AQCR engine mix are present below along with the factors based on a "national mix" [3].

Pollutant	AQCR-70 Emission Factor ($lb/10^3$ gallon)	Nationwide Emission Factor ($lb/10^3$ gallon)
Particulates	25.	25.
Sulfur Oxides	57.	57.
Carbon Monoxide	124.	130.
Hydrocarbons	121.	94.
Nitrogen Oxides	340.	370.

As there is no differentiation in emission factors by engine type for particulates and sulfur oxides in AP-42, the AQCR factor exactly equals the nationwide mix factor. The derived carbon monoxide and nitrogen oxide

emission factors are also not significantly different from nationwide averages. The hydrocarbon emission factor for the AQCR, however, is approximately thirty percent greater than the national average. This results from the high concentration of switch engine (yard) activity in the St. Louis area. Switch engines tend to emit a greater amount of hydrocarbons than line haul locomotives.

As verification of the results of this analysis, a 1973 estimate of railroad fuel use in the St. Louis AQCR was obtained from the National Emissions Data System (NEDS) [1]. This estimate, based on a different allocation procedure, indicated total annual fuel use by railroads to be 62,700,000 gallons, twelve percent less than estimated through the present methodology. This difference is less than the variance associated with the two different allocation procedures, indicating that the methodology presented in this report provides an accurate estimation of railroad fuel use.

V. REFERENCES

1. National Emissions Report, 1973, U.S. Environmental Protection Agency, Report No. EPA-450/2-76-007, Research Triangle Park, NC, May 1976.

2. St. Louis Air Pollution Data Base, Transportation Systems Center, Cambridge, MA, September 1974.

3. Compilation of Air Pollutant Emission Factors, Environmental Protection Agency, Report No. AP-42, Research Triangle Park, NC, Second Edition and Supplements 1-6.

4. Personal Communication with Mr. R. Vogt and Mr. J. Innis, General Motors Electromotive Division, Public Relations Department, LaGrange, IL.

5. Personal Communication with Mr. Frank Loren, Montreal Locomotive Works (ALCO), Montreal, Quebec.

6. Personal Communication with Mr. J. McDermitt, General Electric Company, Erie, PA.

7. Hare, Charles, Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines, Part I: Locomotive Diesel Engines and Marine Equivalents, prepared by Southwest Research Institute, Environmental Protection Agency, Ann Arbor, Michigan, EPA Report No. APTD-1490, March 1973.

APPENDIX A

COMPUTER PROGRAM DESCRIPTIONS AND RUNSTREAMS

NAME: CRLBARAY (GRID PREPROCESSING PROGRAM)

1. RUN DESCRIPTION

CRLBARAY is used to provide a cross-reference of grid number and boundary location as a function of UTM coordinates. The input to the program is RAPS grid system, which includes for each grid, the grid number, its southwest corner coordinate and the grid size (area). The program assigns to each integral UTM coordinate pair within the grid and to the west and south boundaries, a location indicator and the grid number. The location codes are:

Code	Condition
0	Not in AQCR
1	Corner of a grid
2	"X" boundary but not a "Y" boundary
3	Inside the grid but not on any boundary
4	"Y" boundary but not a "X" boundary

The program builds an array of codes and grid numbers which are output to disk for use by the subsequent programs. The flow chart for this program is illustrated in Figure A-1.

2. INPUT-OUTPUT DESCRIPTION

2.1 INPUT

A. Card or Tape or Disk Input:

Title: GRIDS

Record Format: Card Format

Description: This file contains the RAPS grid system. The record description is given in Table A-1.

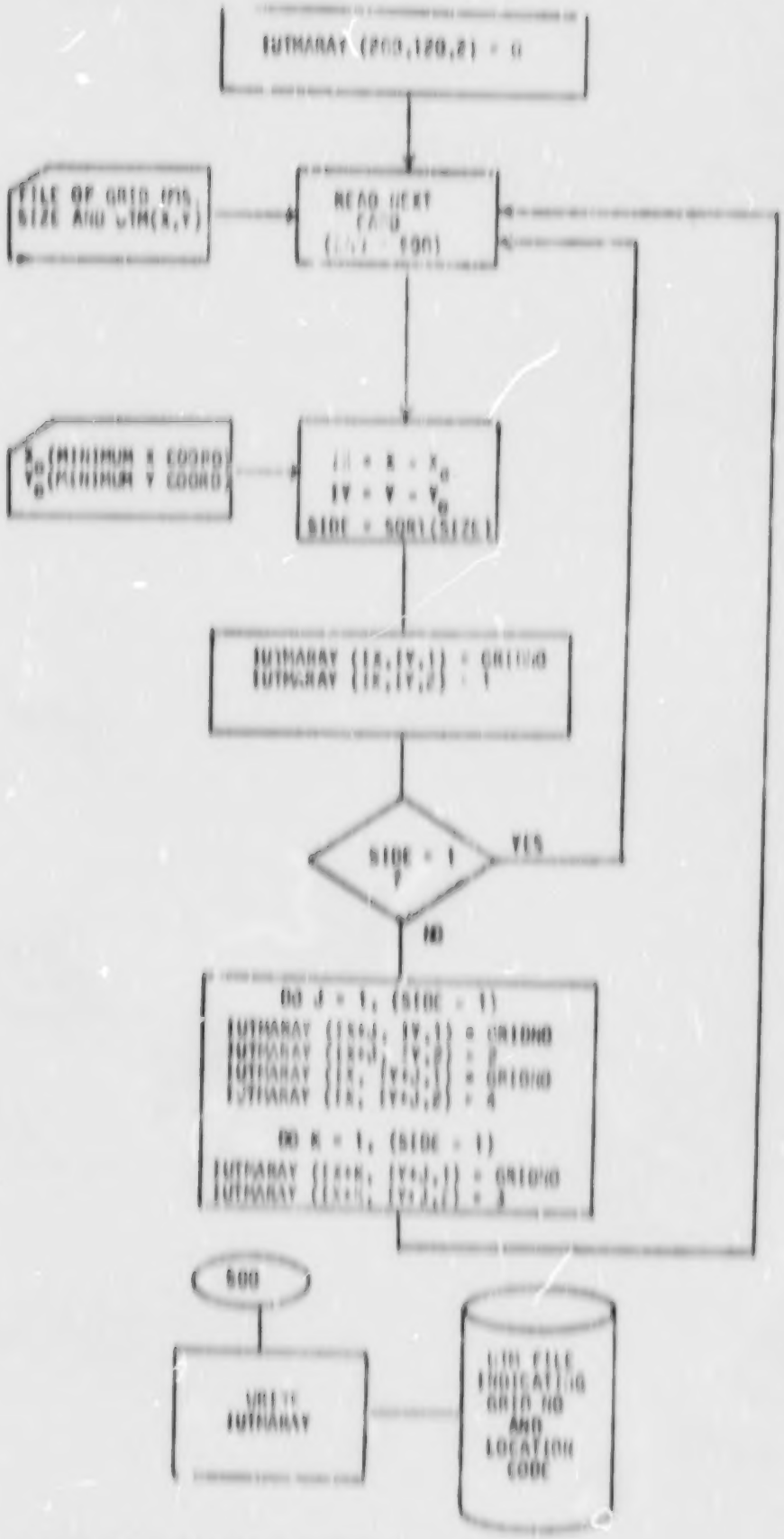

FIGURE A-1 CREGARAY PROGRAM FLOW CHART

TABLE A-1

RECORD DESCRIPTION

Record Position		Length	Data Item Picture	Data Item Name	Description
First	Last				
1	4	4	I4	IGND	RAPS grid number
5	9	5	I5	ISIZE	Size of the grid
10	18	9	F9.1	X	X UTM Coordinate of the south-west corner of the grid
19	26	8	F8.1	Y	Y UTM coordinate of the south-west corner of the grid

2.2 OUTPUT

a. Disk Output

Title: PPROZ

Record Format: Unformatted

Description: The dimensioned array IUTM (210,150,2) is output. This array stores the grid number and the location code for each pair of integral UTM coordinates within the grid system.

b. Printed Output

Selected values of the array IUTM are printed to check the results. At the end of the processing message "ALL RECORDS HAVE BEEN PROCESSED" is printed.

3. RUNSTREAM

The runstream for executing program CREBARAY on the UNIVAC computer is illustrated in Figure A-2. This program has a large array and therefore it requires a large amount of core. To get around this difficulty on UNIVAC the following statement was used as the first statement in the source code:

COMPILER (XM=1)

In addition the array was placed in a labeled COMMON statement.

```
@RUN, accounting information
@ASG,A GRID5
@ASG,CP PPROZ
@USE 5, GRID5
@USE 8, PPROZ
@FOR, IS CREB
        CREBARAY source statements with the arrays in a
        common statement labeled ABC.
@MAP,E CREB
      IN CREB
      IN ABC
END
@XQT CREB
@FIN
```

FIGURE A-2
RUNSTREAM FOR PROGRAM CREBARAY

NAME: GRIDPCT (LINK-TO-GRIDS PROGRAM)

1. RUN DESCRIPTION

GRIDPCT program determines the length of the link between each origin and destination and the percent of this length which is included in each grid. The inputs to the program are the cross-reference file output by CREBARAY and the card file of coded rail segments corrected by means of the ROADMAP plot.

This program determines for each rail segment comprising a rail link between a given origin and destination.

- the grid(s) containing each end of the segment.
- the grids not containing the end points but which are intersected by the segment.
- the length of the segment in each grid
- a running total of link length

After processing all links and segments the length of rail by grid is normalized and three files are output to disk. These are:

- The length of each link connecting an origin-destination
- A file of grids containing the percent of each link the grid contains
- A cross-reference key for these files

The flow chart of this program is illustrated in Figure A-3.

2. INPUT-OUTPUT DESCRIPTION

2.1 INPUT

a. Card, or Tape or Disk Input:

Title: LINK
Record Format: Card Format
Description: This file contains the coded rail segments corrected by means of the ROADMAP plot. The record description is given in Table A-2.

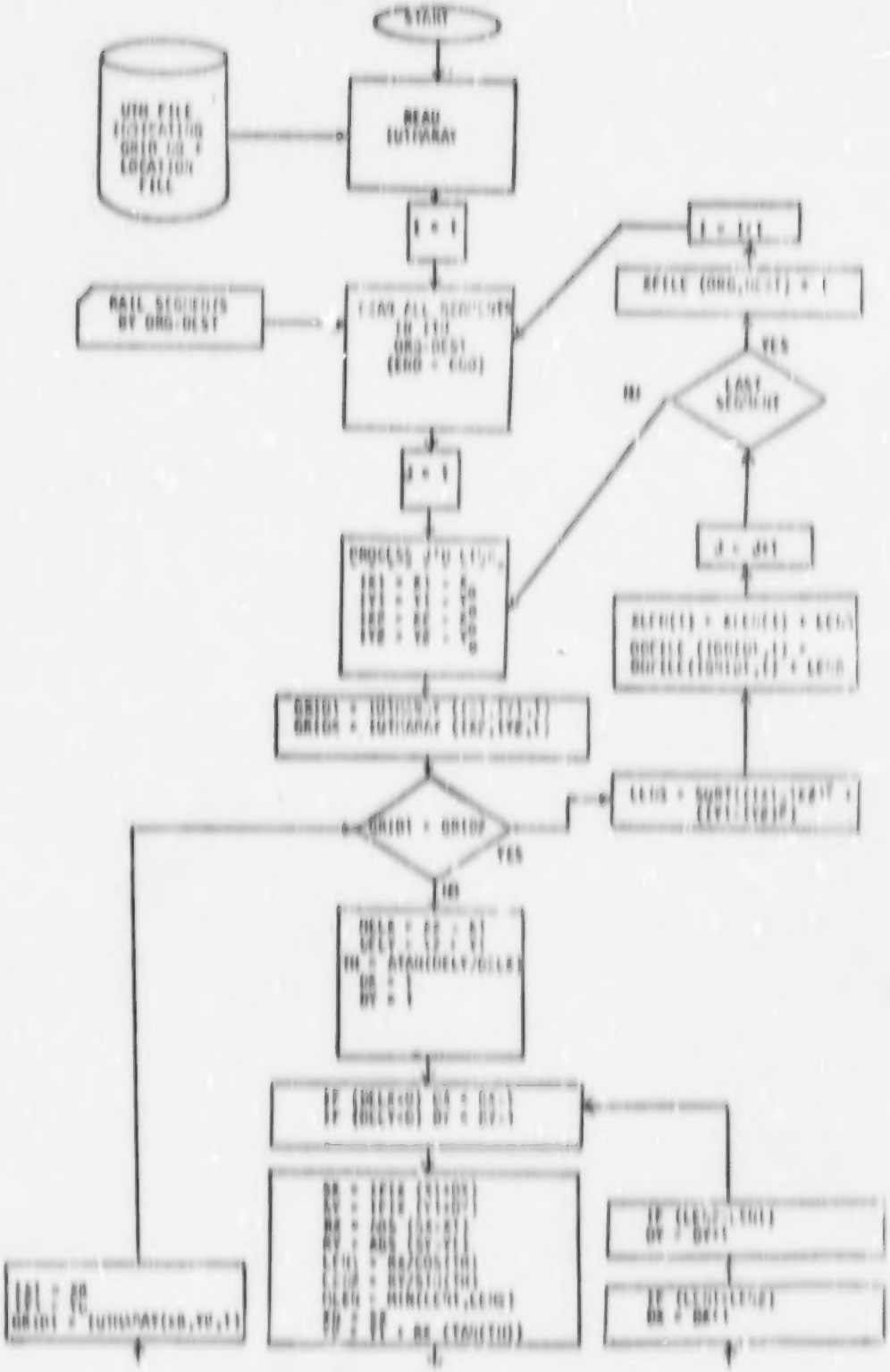

FIGURE A-3

GRIDPCT PROGRAM FLOW CHART

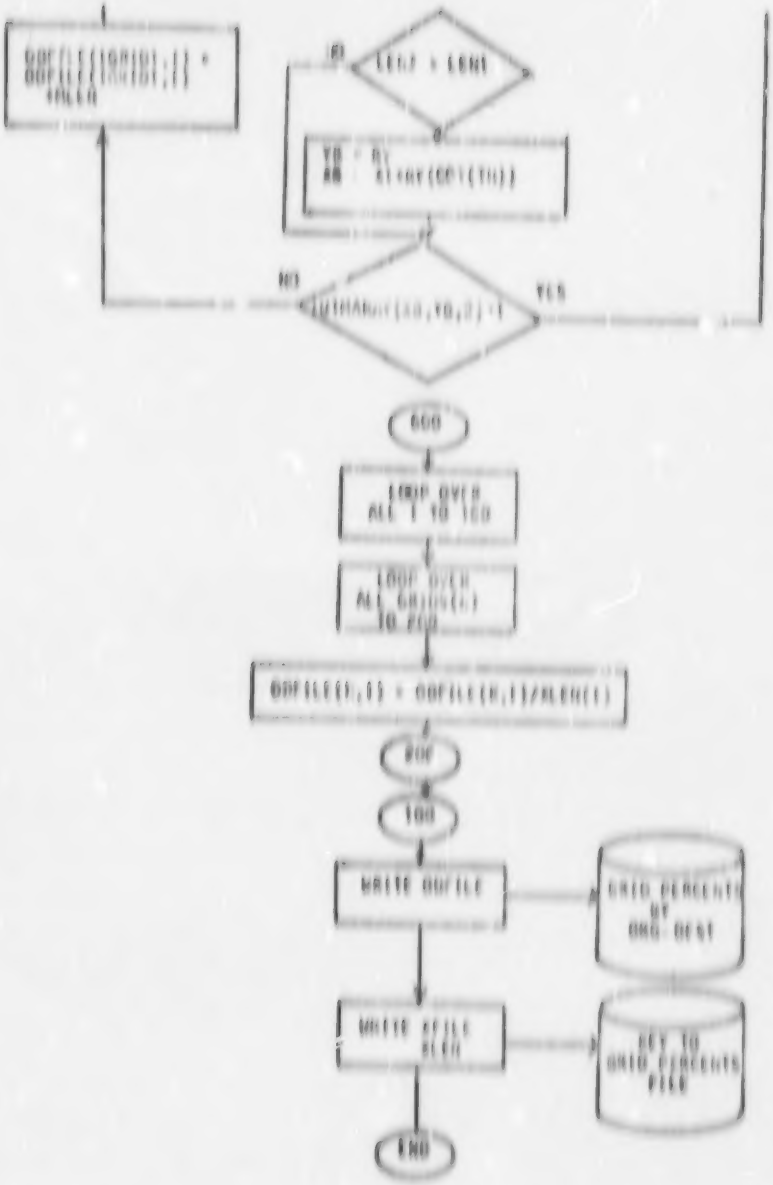

FIGURE A-3
GRIDPCT PROGRAM FLOW CHART (CONTINUED)

TABLE A-2

RECORD DESCRIPTION

Record Position		Length	Data Item Picture	Data Item Name	Description
First	Last				
1	3	3	I3	OR	Origin number of the Link
4	6	3	I3	DT	Destination number of the link
9	10	2	I2	JSEG	Segment number of the link
11	16	6	F6.1	X1	X coordinate of the beginning of the segment
17	22	6	F6.1	Y1	Y coordinate of the beginning of the segment
23	28	6	F6.1	X2	X coordinate of the end point of the segment
29	34	6	F6.1	Y2	Y coordinate of the end point of the segment

b. Disk Input

Title: PPROZ

Record Format: Unformatted

Description: This is the output file generated by the CREWARAY program consisting of location codes and grid numbers.

2.2 OUTPUT

a. Disk Output

1. Title: ODFILE

Record Format: Unformatted

Description: This is a file of grids containing the percent of each link the grids contain.

2. Title: IXFILE

Record Format: Unformatted

Description: This file has the identifying key for each link by its origin and destination. In other words, it is a cross-reference key file for the files ODFILE, and XLEN.

3. Title: XLEN

Record Format: Unformatted

Description: This file has the length of each link by its identifying key.

b. Printed Output

At the end of each segment in every link the grid number in which this end was lying, the length of the link up to this point and the length of the segment in the last grid are printed. When all the segments for any link have been processed then its identifying key, origin and destination numbers, length of link in the last grid and its total length are printed. At the end of the run a message "ALL RECORDS HAVE BEEN PROCESSED" is printed.

3. RUNSTREAM

The runstream for executing program GRIDPCT on the UNIVAC computer is illustrated in Figure A-4. All the big arrays of this program are placed in a labeled COMMON statement so that additional core for the COMMON statement can be obtained.

```
@RUN, accounting information
@ASG,A PPROZ
@ASG,A LINK
@ASG,CP ODFILE
@ASG,CP IXFILE
@ASG,CP XLEN
@USE 5, LINK
@USE 8, PPROZ
@USE 9, ODFILE
@USE 10, IXFILE
@USE 11, XLEN
@FOR, IS PCT
        GRIDPCT source statements with the arrays in a
        common statement labeled ABC.
@MAP,E PCT
      IN PCT
      IN ABC
END
@XQT PCT
@FIN
```

FIGURE A-4
RUNSTREAM FOR PROGRAM GRIDPCT

NAME: QDCHEK (RAIL ACTIVITY QUALITY CONTROL PROGRAM)

1. RUN DESCRIPTION

This program provides a quality assurance check on the routing of road trains. The inputs include the card file of rail routing plus the cross-reference key created by the GRIDPCT program. This program provides a printout of origin destinations which were not represented by the first coding of rail links. Two conditions cause an origin-destination to be flagged. These are:

- The Railroad inventory study [2] skipped certain intermediate nodes in providing the routing or,
- A keypunch or coding error occurred.

Corrections and additions to the input files will be made as a result of the processing. The flow chart for this program is illustrated in Figure A-5.

2. INPUT-OUTPUT DESCRIPTION

2.1 INPUT

a. Card or Tape or Disk Input

Title: RDB
Record Format: Card Format
Description: This file contains the Road train activity data.

b. Disk Input

Title: IXFILE
Record Format: Unformatted
Description: This file was created by the GRIDPCT program and contains the cross-reference keys for the origin and destination of the links input to GRIDPCT program.

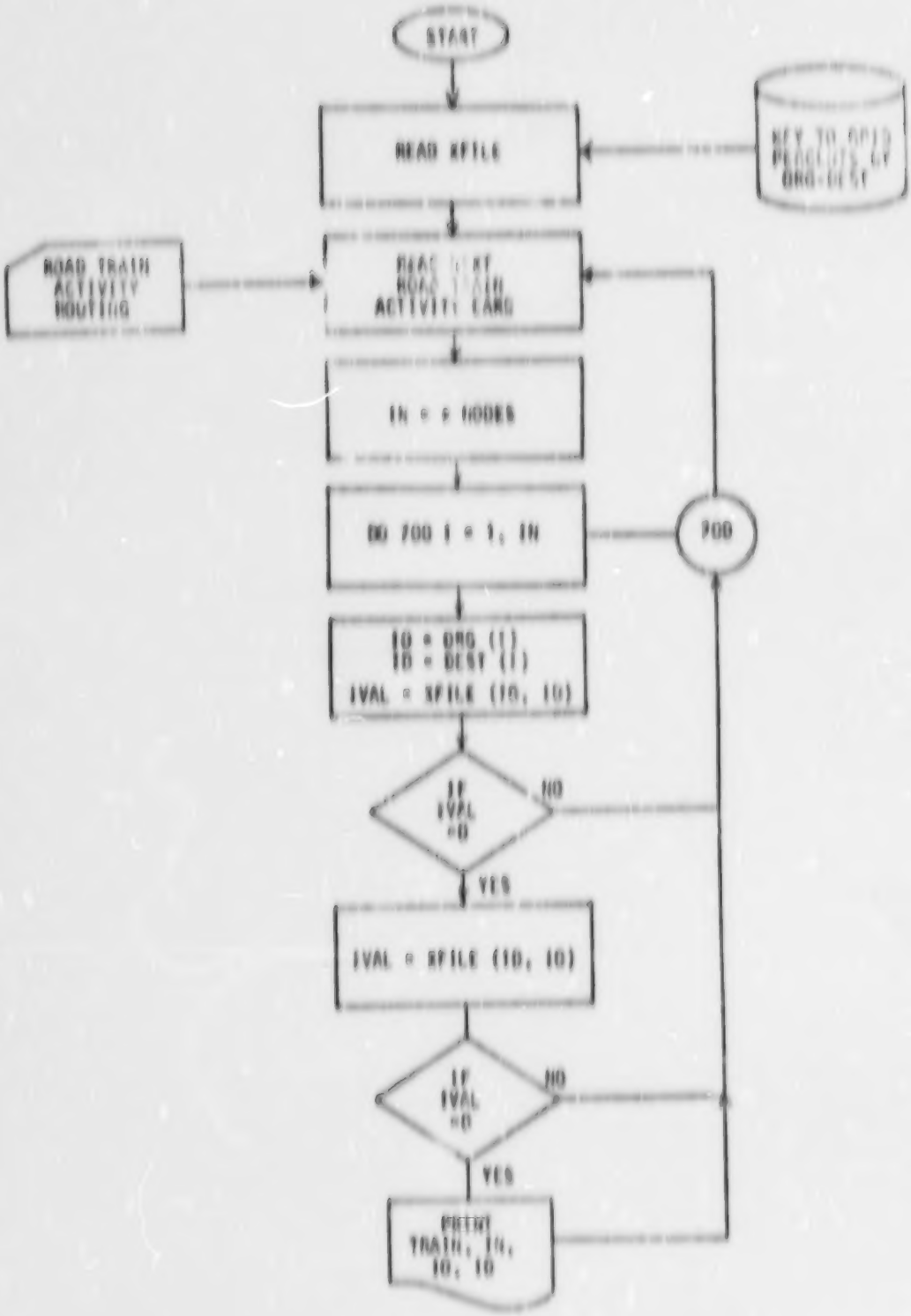

FIGURE A-5 DUCHEK PROGRAM FLOW CHART

2.2 OUTPUT

a. Printed Output

This program flags out any records which have origin destinations not present in the file IXFILE. In addition, it also flags out records which have total run time less than the total link time or if the horse power of any engine is out of range.

3. RUNSTREAM

The runstream for executing program ODCHEK on the UNIVAC computer is illustrated in Figure A-6.

```
@RUN, accounting information
@ASG,A RDB
@ASG,A TXFILE
@USE 5, RDB
@USE 8, TXFILE
@FOR, IS ODCH
        ODCHEK source statements
@MAP, ODCH
      IN ODCH
END
@XQT  ODCH
@FIN
```

FIGURE A-6
RUNSTREAM FOR PROGRAM ODCHEK

NAME: RDALCG (Allocation of Road and Transfer Train Activity Program)

1. RUN DESCRIPTION

The purpose of this program is to allocate non-yard activity to grids. The inputs include the road and transfer train activity and the outputs of GRIDPCT program. This program determines for each rail activity, the horsepower-hours, by engine type, used between two nodes and then allocates this to grid. The output of this program is written to disk in the form of the total horsepower-hours by grid and engine type. The flow chart for this program is illustrated in Figure A-7.

2. INPUT-OUTPUT DESCRIPTION

2.1 INPUT

a. Card or Tape or Disk Input

Title: RDS

Record Format: Card Format

Description: This file contains the Road train activity data and transfer hour data separated by a blank card.

b. Disk Input

1. Title: IXFILE

Record Format: Unformatted

Description: This file contains the cross-reference keys generated by the GRIDPCT program.

2. Title: ODFILE

Record Format: Unformatted

Description: This is the grids file containing the percentage of each link in the grids, generated by the GRIDPCT program.

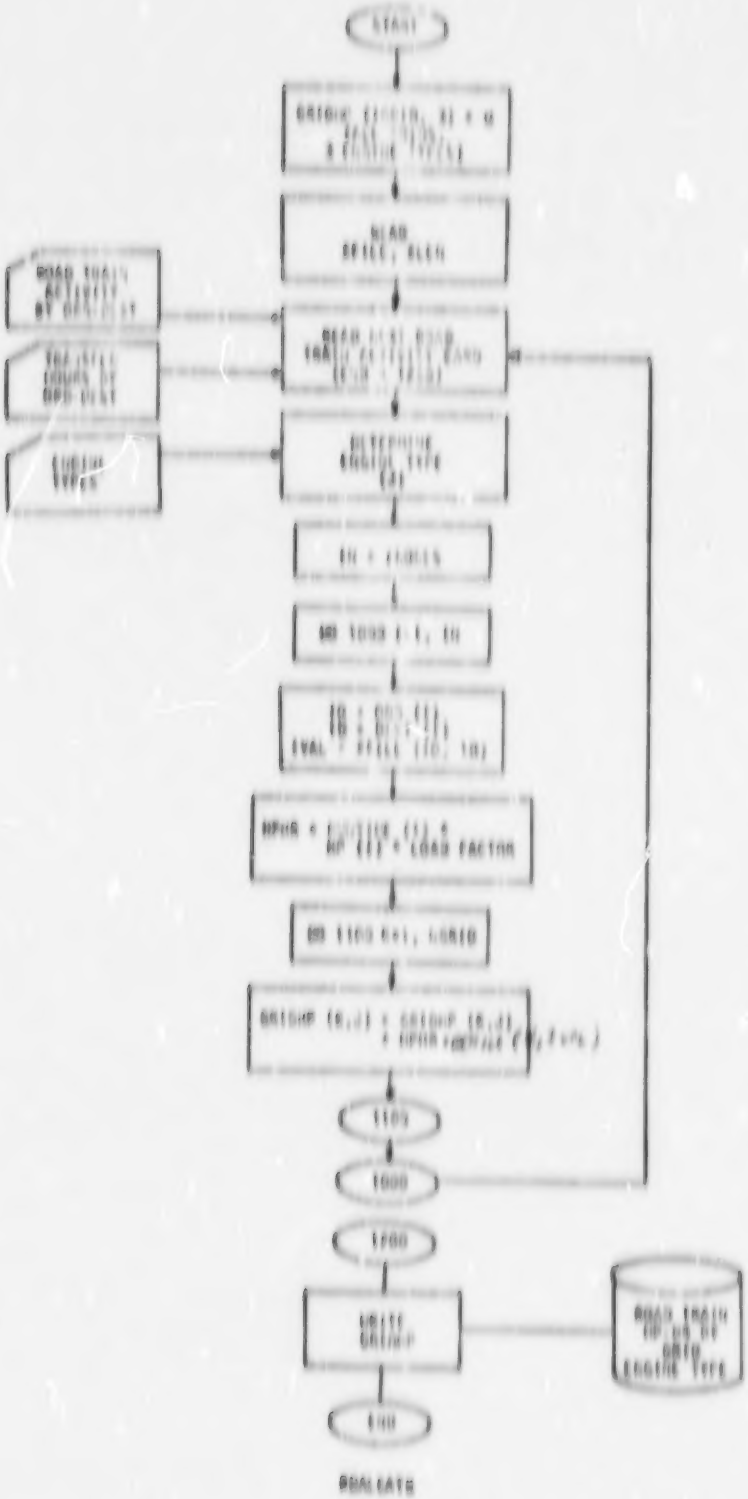

FIGURE A-7
RDALCS PROGRAM FLOW CHART

2.2 OUTPUT

a. Disk Output

Title: GRIDHP

Record Format: Unformatted

Description: This file contains the total horsepower-hours for non-yard activity by grid and engine type.

b. Printed Output

The program produces a listing of each train type and its origin and destination. At the end of the processing it prints the message "ALL RECORDS HAVE BEEN PROCESSED".

3. RUN STREAM

The runstream for executing RDALCB on the UNIVAC computer is illustrated in Figure A-8. Note, that all the big arrays are placed in a labeled COMMON statement.

```
@RUN, accounting information
@ASG,A RDB
@ASG,A IXFILE
@ASG,A ODFILE
@ASG,CP GRIDHP
@USE 5, RDB
@USE 8, IXFILE
@USE 9, ODFILE
@USE 10, GRIDHP
@FOR, TS ROAD
        RDALCB source statements with the arrays in a
        common statement labeled ABC
@MAP,E ROAD
      IN ROAD
      IN ABC
END
@XQT ROAD
@FIN
```

FIGURE A-6
RUNSTREAM FOR PROGRAM RDALCB

NAME: YDALCO (Allocation of Yard Activity Program)

1. RUN DESCRIPTION

This program allocates locomotive activity in yards to the grid system. The program reads coded switch engine activity (idle and active) and road engine idling by yard, plus a file or frid number and percent by yard coded from the U.S.G.S. maps and an identification of engine types. These are then stored in an array referenced by grid number and engine type. After processing all yards, this array is then written to disk. The flow chart for this program is illustrated in Figure A-9.

2. INPUT - OUTPUT DESCRIPTION

2.1 INPUT

a. Card or Tape or Disk Input

Title: YDB

Record Format: Card Format

Description: This file contains the coded cards for three types of data separated by blank cards. The first type of cards contain the yard numbers and yard percentage in different grids by grid number. The second type of cards have the yard activity and the third type of cards have the Road Engine Idling time.

2.2 OUTPUT

a. Disk Output

Title: YDHP

Record Format: Unformatted

Description: This file contains the horsepower-hours for yard activity by grid and engine type.

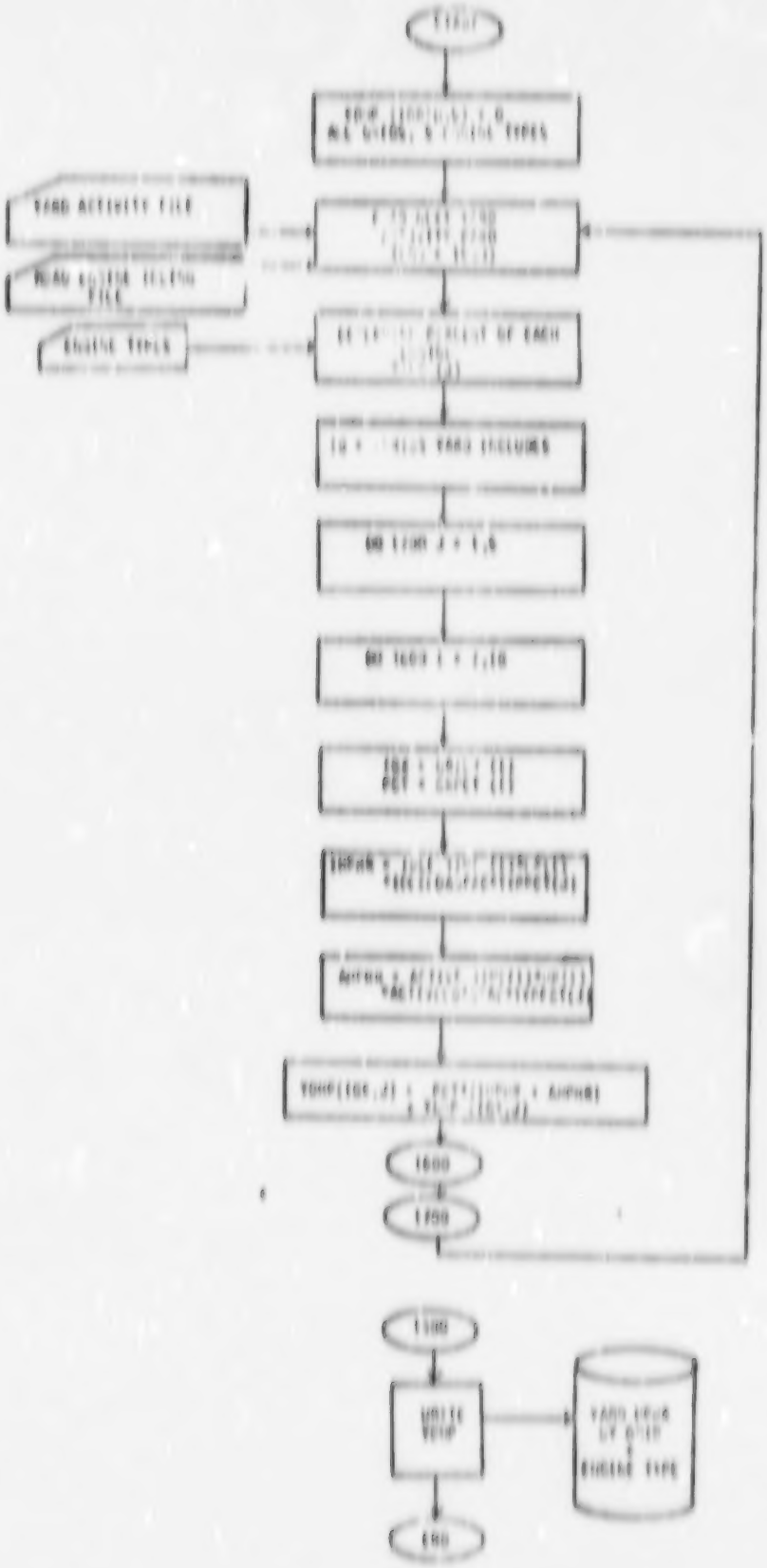

FIGURE A-9

YDALCB PROGRAM FLOW CHART

b. Printed Output

A list of horsepower hour and engine type is produced for the Switch Engine yard data. At the end of the processing a message "ALL RECORDS HAVE BEEN PROCESSED" is produced.

3. RUNSTREAM

The runstream for executing YDALCB on the UNIVAC computer is illustrated in Figure A-10.

```
@RUN, accounting information
@ASG,A VOB
@ASG,CP VOHP
@USE 5, VOB
@USE 6, VOHP
@FOR, IS VARU
          YDALCB source statements
@MAP, VARO
      IN VARO
END
@XQT VARO
@FIN
```

FIGURE A-10
RUNSTREAM FOR PROGRAM YDALCB

NAME: COMBINE (Program to Merge Files)

1. MAIN DESCRIPTION

This program combines the road and yard activity files into a master file which summarizes all locomotive activity (horsepower-hours) by grid and engine type. The program uses the output files of RDALCB and YDALCB and writes the output to a disk file. The flow chart for this program is illustrated in Figure A-11.

2. INPUT-OUTPUT DESCRIPTION

2.1 INPUT

a. Disk Input

1. Title: GRIDHP
Record Format: Unformatted
Description: This file has the non-yard activity by grid and engine type generated by RDALCB program.

2. Title: YDHP
Record Format: Unformatted
Description: This file has the yard activity by grid and engine type generated by YDALCB program.

2.2 OUTPUT

a. Disk Output

Title: THPHR
Record Format: Unformatted
Description: This file contains the total horsepower-hours for all locomotive activity by grid and engine type.

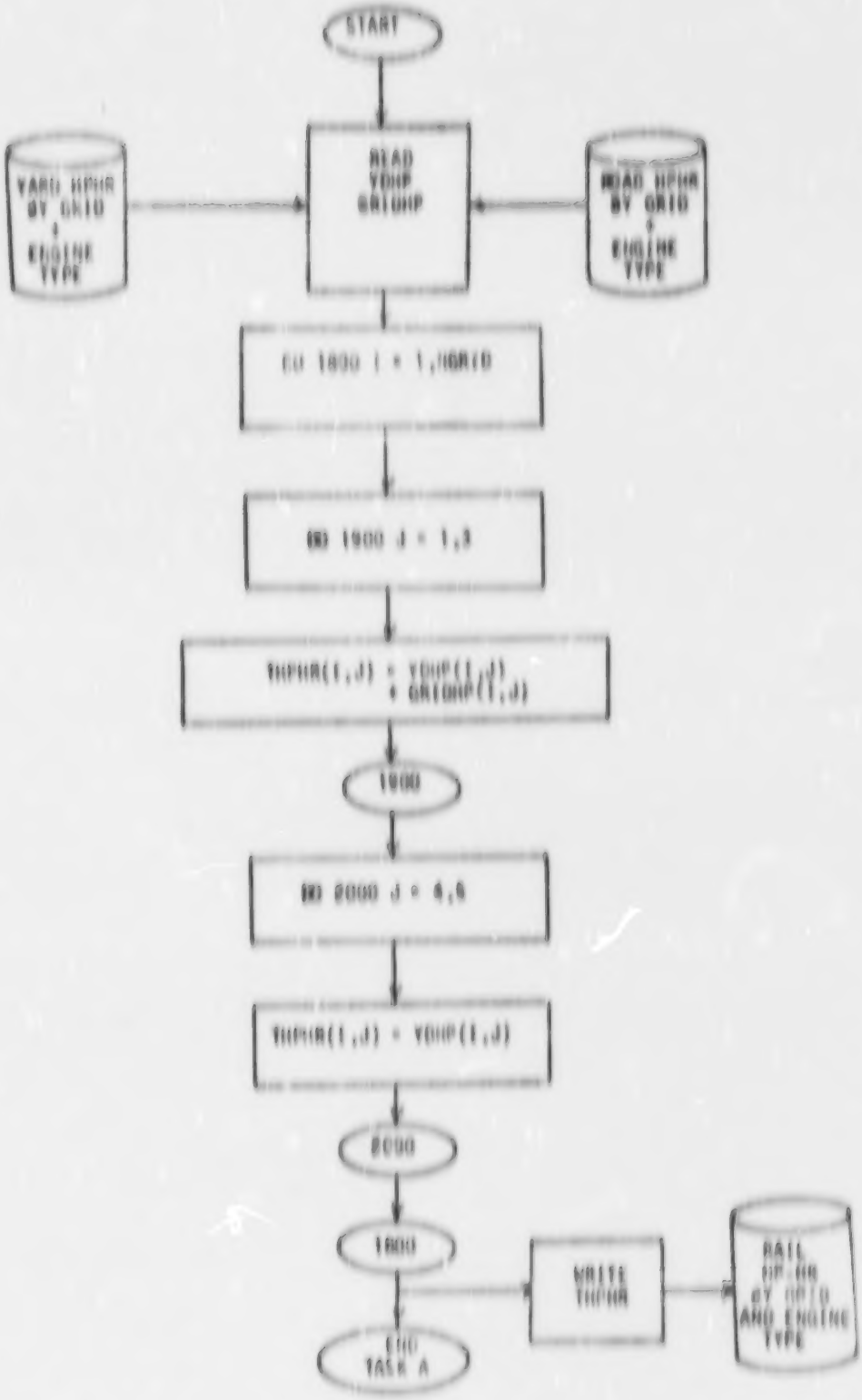

FIGURE A-11
COMBINE PROGRAM FLOW CHART

b. Printed Output

This program lists the yard activity and non-yard activity horse power-hours by grid number and engine type. At the end of the processing sum of all the emissions is printed as well as the message "ALL RECORDS HAVE BEEN PROCESSED".

3. RUNSTREAM

The runstream for executing COMBINE program on the UNIVAC computer is illustrated in Figure A-12.

```
@RUN, accounting information
@ASG,A GRIDHP
@ASG,A VDHP
@ASG,CP THPHR
@USE 8, GRIDHP
@USE 9, VDHP
@USE 10, THPHR
@FOR, IS CMBN
        COMBINE source statements with the arrays in a
        common statement labeled ABC.
@MAP,E CMBN
      IN CMBN
      IN ABC
END
@XQT CMBN
@FIN
```

FIGURE A-12
RUNSTREAM FOR PROGRAM COMBINE

NAME: EMISSION (Program to Compute Fuel Use and Emissions)

1. BUILDESCRIPTION

This program computes fuel use and emissions by grid. The input to this program is the file of total horsepower-hours by grid and engine type created by the COMBINE program. The output includes a card file of annual fuel use by engine type, grid fuel use, and total grid emissions of five pollutants; a print file presenting total annual fuel use and emissions by grid; and an AQCR summary file which is the summation of computed grid fuel use and emissions.

2. INPUT-OUTPUT DESCRIPTION

2.1 INPUT

1. Disk Input

Title: THPHR
Record Format: Unformatted
Description: This file has the horsepower-hours for all locomotive activity by grid and engine type generated by the COMBINE program.

2.2 OUTPUT

a. Disk Output

Title: EMISSION
Record Format: Card Format
Description: This file contains annual fuel use by engine type grid fuel use, and total grid emissions of five pollutants.

b. Printed Output

This program produces a listing of total annual fuel use and emissions by grid, and an AQCR summary file.

3. RUN STREAM

The runstream for executing EMISSION program on the UNIVAC computer is illustrated in Figure A-13.

```
@RUN,        accounting information
@ASG,A       THPHR
@ASG,CP      EMISSION
@USE      11,THPHR
@USE       8,EMISSION
@FOR,IS      EMSN
             EMISSION source statements
@MAP,        EMSN
          IN EMSN
END
@XQT         EMSN
@FIN
```

FIGURE A-13
RUNSTREAM FOR PROGRAM EMISSION

APPENDIX B

INPUT DATA CODING FORMATS

COORDINATES OF LINE SEGMENTS DEFINING LINKS

Columns	Format	Units	Description
1-3	XXX	-	Origin of Link in Which Segment Occurs
4-6	XXX	-	Destination of Link in Which Segment Occurs
7-10	XXXX	-	Segment Number
11-16	XXXX.X	UTM*	X-Coordinate of Beginning of Segment
17-22	XXXX.X	UTM	Y-Coordinate of Beginning of Segment
23-28	XXXX.X	UTM	X-Coordinate of End Point of Segment
29-34	XXXX.X	UTM	Y-Coordinate of End Point of Segment
35-80	Blank	-	Unused

* Note UTM in kilometers, common zone

Origin	Destination	Series	LTP				Coordinates of Line Segments Defining Lines
			Start		End		
			X	Y	X	Y	

ROAD TRAIN ACTIVITY CARD TYPE 1

#1 Columns	Format	Units	Description
1	A	-	Inbound (I) or Outbound (O) Train
2-4	XXX	-	Origin of Train
5-7	XXX	-	Destination of Train
8-13	AAAAAA	-	Destination Yard if Inbound Train Origin Yard if Outbound Train
15-20	AAAAAA	-	Train Name
22	X	-	Number of Engine Types
24-26	AAA	-	Make of First Engine Type
28-31	XXXX	hp	Horsepower of First Engine Type
33-36	XXXX	hrs/mins	Run Time (Hours in Columns 33,34; Minutes in Columns 35,36)
38	X	-	Number of Type 1 Engines
40-42	AAA	-	Make of Second Engine Type
44-47	XXXX	hp	Horsepower of Second Engine Type
49-52	XXXX	hrs/mins	Run Time (Hours in Columns 49,50; Minutes in Columns 51,52)
54	X	-	Number of Type 2 Engines
56-58	AAA	-	Make of Third Engine Type
60-63	XXXX	hp	Horsepower of Third Engine Type
65-68	XXXX	hrs/mins	Run Time (Hours in Columns 65,66; Minutes in Columns 67,68)
70	X	-	Number of Type 3 Engines
72-76	AAAAA	-	Name of Railroad
77-78	XX	-	Reference Number (Arbitrary)
80	1	-	Card Type (#)
14,21,23,27,32 37,39,43,48,53 55,59,64,69,71,79	BLANK	-	Unused

ROAD TRAIN ACTIVITY CARD TYPE 2

#2 Columns	Format	Units	Description
1	A		Inbound (I) or Outbound (O) Train
2-4	XXX	-	Origin of Train
5-7	XXX	-	Destination of Train
8-13	AAAAAA	-	Destination Yard if Inbound Train Origin Yard if Outbound Train
15-20	AAAAA	-	Train Name
22	X	-	Number of Nodes
24-26	XXX	-	Entry Node if Inbound Train Exit Node if Outbound Train
27-30	XXXX	hrs/mins	Link Time - Time Between Nodes (Hours in Columns 27,28; minutes in columns 29,30)
32-34	XXX	-	Node 2
35-38	XXXX	hrs/mins	Link Time (Hours in Columns 35,36; Minutes in Columns 37,38)
40-42	XXX	-	Node 3
43-46	XXXX	hrs/mins	Link Time (Hours in Columns 43,44; Minutes in Columns 45,46)
48-50	XXX	-	Node 4
51-54	XXXX	hrs/mins	Link Time (Hours in Columns 51,52; Minutes in Columns 53,54)
56-58	XXX	-	Node 5
59-62	XXXX	hrs/mins	Link Time (Hours in Columns 59,60; Minutes in Columns 61,62)
64-66	XXX	-	Node 6
72-76	AAAAA	-	Name of Railroad
77-78		-	Reference Number (Arbitrary)
80	X		Card Type (#)

Direction	
Origin	
Destination	
Origin or Destination Yard	
Train Name	
Number of Nodes	
Entry or Exit Node	
Link Time	
Node 2	Next Train Activity Card Type 2
Link Time	
Node 3	
Link Time	
Node 4	
Link Time	
Node 5	
Link Time	
Node 6	
Railroad	
Reference #	
Card Type	

Direction	
Origin	
Destination	
Origin or Destination Yard	
Train Name	
Number of Engine Types	
Make	Next Train Activity Card Type 3
Horsepower	
Run Time	
# of Units	
Make	
Horsepower	
Run Time	
# of Units	
Make	
Horsepower	
Run Time	
# of Units	
Railroad	
Reference #	
Card Type	

ROAD TRAIN UNITS IDLING IN YARDS

#3 Columns	Format	Units	Description
1-6	AAAAAA	-	Yard Name
8-10	XXX	-	Yard Name
12-17	AAAAAA	-	Train Name
19	X	-	Number of Engine Types
21-23	AAA	-	Make a First Type
25-28	XXXX	hp	Horsepower of First Type
30-33	XXXX	hrs/mins	Idle Time (Hours in Columns 30,31; Minutes in Columns 32,33)
35	X	-	Number of Engines in First Type
37-39	AAA	-	Make of Second Type
41-44	XXXX	hp	Horsepower of Second Type
46-49	XXXX	hrs/mins	Idle Time (Hours in Columns 46,47; Minutes in Columns 48,49)
51	X	-	Number of Engines in Second Type
53-55	AAA	-	Make of Third Type
57-60	XXXX	hp	Horsepower of Third Type
62-65	XXXX	hrs/mins	Idle Time (Hours in Columns 62,63; Minutes in Columns 64,65)
67	X	-	Number of Engines in Third Type

Yard Name
Yard Number
Train Name
Number of Engine Types
Make: Type 1
Horsepower: Type 1
Idle Time: Type 1
# of Units
Make: Type 2
Horsepower: Type 2
Idle Time: Type 2
# of Units
Make: Type 3
Horsepower: Type 3
Idle Time: Type 3
# of Units

SWITCH ENGINE ACTIVE AND IDLE TIME IN YARDS

#4 Columns	Format	Units	Description
1-6	AAAAAA	-	Yard Name
9-11	XXX	-	Yard Numbers
15-18	XXXX	hrs/mins	Active Hours (Hours in Columns 15,16; Minutes in Columns 17,18)
23-27	XXXXX	hrs/mins	Idle Hours (Hours in Columns 23-25; Minutes in Columns 26/27)
31	X	-	Numbers of Engine Types
33-36	XXXX	hp	Horsepower of First Engine Type
37	X	-	Engine Classification
38-40	XXX	percent	Percent of Engine Type Operating in Yard
42-45	XXXX	hp	Horsepower of Second Engine Type
46	X	-	Engine Classification
47-49	XXX	percent	Percent of Engine Type Operating in Yard
51-54	XXXX	hp	Horsepower of Third Engine Type
55	X	-	Engine Classification
56-58	XXX	percent	Percent of Engine Type Operating in Yard
60-63	XXXX	hp	Horsepower of Fourth Engine Type
64	X	-	Engine Classification
65-67	XXX	percent	Percent of Engine Type Operating in Yard

Switch Engine Active and Idle Time in Yards

Yard Name	Yard Number	Active Hours		Idle Hours	Number of Engine Types	Horsepower: Type One	Classification & Type One	Horsepower: Type Two	Classification & Type Two	Horsepower: Type Three	Classification & Type Three	Horsepower: Type Four	Classification & Type Four		

TRANSFER ENGINE UNIT HOURS ON LINKS

#5 Columns	Format	Units	Description
1-3	XXX	-	Origin of Transfer Operation
4	Blank	-	Unused
5-7	XXX	-	Distination of Transfer Operation
8	Blank	-	Unused
9-12	XX.X	Hours	Transfer Hours
13-80	Blank	-	Unused

Origin	Destination	Transfer Hours

LOCATION OF AREA YARDS

#6 Columns	Format	Units	Description
1-6	AAAAAA	-	Yard Name
7-10	XXXX	-	Yard Number
11-13	XXX	-	Total Number of Grid Squares in Which Yard is Located
14-17	XXXX	-	Grid Number
18-20	XXX	percent	Percent of Yard in Grid
21-24	XXXX	-	Grid Number
25-27	XXX	percent	Percent of Yard in Grid
28-31	XXXX	-	Grid Number
32-34	XXX	percent	Percent of Yard in Grid
35-38	XXXX	-	Grid Number
39-41	XXX	percent	Percent of Yard in Grid
42-45	XXXX	-	Grid Number
46-48	XXX	percent	Percent of Yard in Grid
49-52	XXXX	-	Grid Number
53-55	XXX	percent	Percent of Yard in Grid
56-59	XXXX	-	Grid Number
60-62	XXX	percent	Percent of Yard in Grid
63-66	XXXX	-	Grid Number
67-69	XXX	percent	Percent of Yard in Grid
70-73	XXXX	-	Grid Number
74-76	XXX	percent	Percent of Yard in Grid
77-80	Blank	-	Unused

Location of Area Yards

Yard Name	Yard #	No. of Grids	Grid Number and Percent of Yard in Grid																	
			#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%

ENGINE CLASSIFICATION

#/ Columns	Format	Units	Description
1-3	AAA	-	Make of Engine
4-6	Blank	-	Unused
7-10	XXXX	hp	Engine Horsepower
11-14	Blank	-	Unused
15	X	-	Engine Classification
16-80	Blank	-	Unused

Engine Classification by Make and Horsepower

Make of Engine		Horsepower	Engine Classification

APPENDIX C

FUEL USE AND EMISSIONS BY GRID

Reproduced from best available copy.